LIVSHITS, B.G.

Moscow. Institut stali

Proizvodstvo i obrabotka stali i splavov (Production and Treatment of Steel and Alloys) Moscow, Metallurgizdat, 1960. 462 p. (Series: Its: Sbornik, 39) 2,100 copies printed.

Ed.: Ye. A. Borko; Ed. of Publishing House: S. L. Zinger; Tech. Ed.: N. M. Kheyman; Editorial Council of the Institut: N. A. Glinkov, Professor, Doctor of Technical Sciences; R. N. Grigorman, Docent, Candidate of Technical Sciences; V. P. Volynin, Professor, Doctor of Technical Sciences; A. A. Zhukhovitskiy, Professor, Doctor of Chemical Sciences; I. M. Kidin, Professor, Doctor of Technical Sciences; B. G. Livshits, Professor, Doctor of Technical Sciences; P. Lyublnov, Professor, Doctor of Technical Sciences; I. N. Pavlov, Corresponding Member, Academy of Sciences USSR; and A. M. Pchelnikov, Professor, Doctor of Technical Sciences.

PURPOSE: This book is intended for technical personnel in industry, scientific institutes and schools of higher education, dealing with open-hearth and electric-furnace steelmaking, metal rolling, physical metallurgy, and heat-treatment. It may

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also be used by students specializing in these fields.

COVERAGE: The book contains results of theoretical and experimental investigations of metallurgical and heat-engineering processes in open-hearth and electric furnaces. Data are included on the following: desulfuring of pig iron outside the blast furnace, interaction of oxides of the carbide-forming metals with solid carbon, the change of content of gases in the bath of the open-hearth furnace in various periods of melting, intensification of search melting of steel, etc. Other articles deal with the nonuniformity of deformation in rolling, the study of the continuous rolling process, the dependence of the friction coefficients in rolling on a number of factors, and other problems in the preworking of metals. Articles on physical metallurgy and the theoretical principles and techniques of the heat treatment of steel are also included. No personalities are mentioned. References accompany most of the articles, both Soviet and non-Soviet.

There are 207 references.

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BELYATSKAYA, I.S.; LIVSHITS, B.G.

Investigating the kinetics of phase transformations in EI617 heat-resistant alloys. Izv. vys. ucheb. zav.; chern. met. no.1: 175-179 '60.   (MIRA 13:1)

1.Moskovskiy institut stali.
        (Heat-resistant alloys) (Phase rule and equilibrium)

85810

18 8100   1138, 1413, 1454

S/148/60/000/003/014/018
A161/A029

AUTHORS: Zakharov, Ye.K.; Livshits, B.G.

TITLE: Allotropic and Magnetic Transformations in Cobalt-Chrome-Titanium Alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. - Chernaya metallurgiya, 1960, No. 3, pp. 125 - 130

TEXT: Allotropy in the Co-Cr-Ti alloys investigated was determined by measuring the magnetization of the alloys during heating and cooling in weak magnetic fields, using an improved Akulov AAГ-50 (AAG-50) anisometer with a more sensitive suspension on longer springs. This anisometer shows a 350 - 400mm shift on the scale in 1.5 m distance during measurements on a 35 mm long specimen of 3 mm in diameter and a 150 - 200 oersted outer magnetic field. The position of the light spot (shift) could be reproduced with ± 1 mm accuracy. The growth of magnetization with allotropic transformation is clearly seen on levelled curve portions. The improved anisometer is insensitive to building vibration and traffic in close vicinity to the premises. Curie points were found with sufficient accuracy in the 20-1,150°C range. The interdependence of Curie points and the alloy compositions was found. The Curie points dropped in alloys with Cr and
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Allotropic and Magnetic Transformations in Cobalt-Chrome-Titanium Alloys

Ti; binary Co-Cr alloys with over 18-19% Cr became fully non-ferromagnetic at room temperature. Some alloys had two Curie points, which indicates a high tendency to overheating and overcooling. The solubility of Ti in Co was stated to be about 8% at 850°C and to drop with decreasing temperature. This nearly fits the value of 7.2% found by Koester (Ref. 5), but is far from the value of 20% found by Livshits and Khorin (Ref. 7). Microphotographs confirmed the magnetic measurement results: beginning heterogeneity was found in a structure with 9% Ti, clear eutectic in the case of 12% Ti; Co-Ti with less than 4% Ti had martensite structure with Co in α-and β-phases. Eutectoid decomposition was observed at more than 8% Ti content. No sign of martensite or eutectic was revealed in structures with 4-8% Ti, and it appears that these processes are inhibited in this Ti-content range. In ternary alloys with Cr:Ti=1 the structures sequence was analogous, and the total solubility of Cr and Ti at 720°C was 8% (4% Cr and 4% Ti). The high difference of data obtained compared with Reference 7 will be discussed later. There are 5 figures and 7 references: 2 Soviet, 3 German, 2 English.

ASSOCIATION: Moskovskly institut stali (Moscow Steel Institute)

SUBMITTED: February 27, 1959

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80595

/P. 7500
/P. 1250

S/148/60/000/005/004/009

AUTHORS: Belyatskaya, I.S., Livshits, B.G.

TITLE: The K-State and Durability of Nickel-Chrome Base Alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Chernaya metallurgiya,
1960, Nr 5, pp 99 - 101

TEXT: The K-state, revealed in a number of single-phase alloys, en-
tails strengthening of interatomic forces in the solid solution. Apparently,
the K-state impedes diffusion processes in heat resistant alloys, in parti-
cular, coagulation of the strengthening phase, and consequently may improve
their heat resisting properties. This was studied by continuous heating and
cooling of ЭИ437 (EI437) and ЭИ617 (EI617) alloys. To reveal the effect of
the K-state on heat resisting properties of EI617 alloy, specimens were
subjected to standard treatment and preliminary standard tempering up to the
K-state (Table 1). Table 1 shows that tempering up to the K-state almost
doubles the durability of the alloys. The positive effect of the K-state on
the heat resistance of EI437 specimens was established by cooling the speci-
mens and by tempering them at 700°C [Ref 7]. Table 2 shows that delayed

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The K-State and Durability of Nickel-Chrome Base Alloys

cooling down to 600°C increased the durability of the specimen. The experiments confirmed G.V. Kurdyumov's theory on the effect of interatomic forces on heat resisting properties. The K-state probably improves also the heat resisting properties during intermittent tempering; this is explained by the fact that nuclei of the α'-phase, forming during cooling periods between the tempering times, grow only slightly, since their coagulation is impeded by the submicroheterogeneity of the solid solution (K-state). This state arises during the multiple cooling and heating processes and is maintained at high temperatures. On the other hand the separation of the α'-phase furthers a fuller development of the K-state, since Al and Ti are eliminated from the solution which becomes more durable during each cycle of tempering. This impedes coagulation of the α'-phase. The use of tempering up to the K-state or the replacement of continuous tempering at 800°C by intermittend tempering may raise the operational temperature or the admissible strain. There are: 2 tables and 7 references, 5 of which are Soviet and 2 German.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: June 22, 1959

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86070

S/180/60/000/C05/011/033

E073/E535

18.1150

AUTHORS: Belyatskaya, I. S. and Livshits, B. G., (Moscow)

TITLE: On the Theory of Phase Transformations in Refractory Nickel-Chromium Base Alloys

PERIODICAL: Izvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh nauk, Metallurgiya i toplivo, 1960, No.5, pp.122-127

TEXT: The authors investigated phase transformations in an industrial nichrome base alloy. The high refractory properties of this alloy are achieved on the one hand by alloying Fe-Cr-Ni solid solution with such high melting point elements as molybdenum and tungsten, which increase the strength of the interatomic bonds of the crystal lattice of a solid solution and slow down the process of softening at elevated temperature and, on the other hand, by introducing titanium and aluminium. Intensive dispersion hardening is achieved as a result of formation of a considerable quantity of a thermally stable inter-metallide of the hardening phase $Ni_3(Al,Ti)$ of the α-type. In addition to studying the kinetics of formation of the K-state in the alloy, the temperature range and the kinetics of other phase transformations were studied. All these specimens were quenched in water after holding for 2 hours at $1200^\circ C$ for the

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On the Theory of Phase Transformations in Refractory Nickel-
Chromium Base Alloys

purpose of obtaining a practically uniform solid solution. To
establish the temperature ranges of phase transformations, the
electric resistance was measured of the quenched specimen in the
process of continuous heating and cooling by a compensation method
using potentiometric apparatus. The K-state was very highly
pronounced (curve 3, Fig.1). Up to 450°C the electric resistance
increased continuously in accordance with the temperature
coefficient of the resistance; between 450 and 900°C an increase in
the electric resistance was observed, which is characteristic for
the K-state. To study in greater detail the kinetics of the
transformations in an alloy quenched from 1200°C, various specimens
were tempered at 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000
and 1050°C for durations of 0.5, 1.5, 3, 5, 10, 16, 20, 25, 50 and
100 hours followed by cooling in water, after which the hardness
and the electric resistance were measured (Fig.2). Tempering at
100, 200, 300 and 400°C does not produce any appreciable change in
the physical properties; at 450 to 800°C the electric resistance
increased, reaching a maximum at 600°C. Above 600°C the resistance
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On the Theory of Phase Transformations in Refractory Nickel-Chromium Base Alloys

decreased both as a result of destruction of the K-state and also as a result of the beginning of the decomposition of the solid solution. The authors also carried out experiments on the processes taking place during a secondary quenching of nichrome base high temperature alloys. The aim of the first series of experiments was to study the speed of dissolution of the hardening α-phase at 1050°C (secondary quenching temperature). Specimens which were quenched from 1200°C and aged at 800°C for 16 hours were held at 1050°C for 30 min to 24 hours and then quenched in water. Following that, the specific resistance and the hardness were measured. Then, the specimens were again aged for 16 hours at 800°C and the resistance and hardness measured. The results, Table 2, indicate that the hardness does not change appreciably as a result of the holding time at 1050°C. Long run strength tests have shown that the optimum temperature for secondary quenching of the alloy is 1000 to 1050°C; the microstructure of such specimens shows a relatively uniformly distributed network of relatively large carbide particles along the grain boundaries. The best refractory

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On the Theory of Phase Transformations in Refractory Nickel-Chromium Base Alloys

properties of nickel-chrome base alloys are obtained in the case of the following transformations taking place successively in the uniform solid solution after quenching from a high temperature: rejection of the hardening grain boundaries of the carbide phase; ageing which leads to rejection of an inter-metallide hardening phase throughout the body of the grain and formation of a fine sub-microscopic non-uniformity (K-state) in the basic solid solution. The role of the K-state reduces to that of hardening to some extent the basic solid solution by influencing mainly the slowing down of diffusion processes in the alloy and preventing coagulation of the strengthening α-phase. There are 3 figures, 2 tables and 8 references: 6 Soviet, 1 German and 1 English.

SUBMITTED: July 6, 1960

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S/148/60/000/005/008/009

AUTHORS: Verigina, Z.S., Livshits, B.G.

TITLE: Determination of Critical Points in Commercial Titanium Alloys
              BT-3 (VT-3) and BT-3-1 (VT-3-1)

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy, Chernaya metallurgiya,
              1960, Nr 5, pp 163 - 171

TEXT: The commercial titanium alloys VT-3 and VT-3-1 (composition
given in a table) become brittle after conventional thermal treatment. To
explain the causes of such brittleness and to select the appropriate thermal
treatment for eliminating same the authors undertook to determine the upper
and lower critical points and the cooling rates ensuring the equilibrium
state at low temperatures. To determine the upper critical points the
specimens were water-cooled from various temperatures. Heating was performed
in a vertical furnace in argon atmosphere. Additionally, X-ray analyses were
carried out with the use of data submitted by Yu.A. Bagaryatskiy, T.V. Tagunova
and G.I. Nosova [Ref 4]. To determine the lower critical points and cooling
conditions entailing the equilibrium phase state, the specimens were cooled at

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Determination of Critical Points in Commercial Titanium Alloys BT-3 (VT-3) and BT-3-1 (VT-3-1)

different rates from the β-zone (500, 200, 100, 80, 60 and 40 degrees per hour, and the VT-3 alloy at 15 degrees per hour). In alloys cooled down to the equilibrium state, electric resistances were measured during heating and cooling (Figure 5). It was established that the single-phase β-zone was obtained for VT-3 by heating up to 1,100°C and for VT-3-1 to 1,000°C. The lower critical point (probably the eutectoid one) was for VT-3 equal to 580°C ± 10, and for VT-3-1 500°C ± 10. The replacement of 0.75% chromium by 1.7% molybdenum reduced the upper and lower critical points approximately by 100°C. The annealing structure of the VT-3 alloy was obtained by a cooling rate of 15°/hour and of VT-3-1 by that of 40°/hour. There are: 1 table, 4 sets of microphotos, 2 sets of graphs and 4 references, 3 of which are English and 1 Soviet.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: November 17, 1959

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83291

S/148/60/000/007/012/015
A161/A029

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AUTHORS: Belyatskaya, I.S.; Livshits, B.G.

TITLE: Investigation of Secondary Quenching Effect on the Structure and
Properties of the EI617 Alloy

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallur-
giya, 1960, Nr 7, pp 156-162

TEXT: The purpose of the experiments described was the investigation of
phenomena in secondary quenching of heat resistant "ЭИ617" (EI617) alloy
(15.3% Cr; 1.99% Ti; 1.78% Al; 5.22% W; 0.26% V; 3.89% Mo; 1.38% Fe; 0.05%
B; 0.09% C, the base Ni). The alloy develops dispersion hardening at 700-
900°C, with separation of an intermetalloid phase of $Ni_3(Al,Ti)$ type; the
K- state at lower temperatures remains apparently to 800-900°C. The
standard heat treatment of this alloy are two air quenchings (1,200°C, 2
hours and 1,050°C, 4 hours) and subsequent 16-hours annealing at 800°C
with cooling in air. It is known that quenching from 1,200°C only, with
subsequent annealing, drastically reduces the heat resistance of the alloy,

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considerable changes

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Investigation of Secondary Quenching Effect on the Structure and Properties of the EI617 Alloy

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were revealed. The lattice parameter (3.575 kX) remained unchanged. The following conclusions were drawn: 1) The effect of secondary quenching of the EI617 alloy apparently does not consist in formation of crystallization centers of the intermetalloid strengthening phase only. 2) A carbide phase of $Ni_n Me_m C$ type segregates on the grain boundaries during the second quenching. 3) The results of long-time strength tests prove that the optimum temperature for secondary quenching of this alloy is $1,000°C$. Such treatment results in the appearance of an evenly distributed chain of comparatively large carbide particles along the grain boundaries. 4) It is possible that the improved alloy properties after secondary quenching are partly due to facilitated formation of K-state because of the transfer of carbon from solution into carbide phase. There are 4 figures, 2 tables and 8 references: 5 are Soviet and 3 English.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: July 7, 1959

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S/148/60/000/009/020/025
A161/A030

AUTHORS: Lakhman, N.G., and Livshitz, B.G.

TITLE: Metallographic investigation of the alfenol alloy

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya,
                no. 9, 1960, 148-156

TEXT: Information is given on the techniques and results of an
investigation of the alfenol alloy developed recently (Ref.1,3) (Abstracter's
note: The sources referred to are J. of Appl. Physics and Metal Progress).
The alloy is highly interesting as magnetically soft material; its draw -
backs are brittleness and heterogeneity of magnetic properties even in a
single heat. The investigation purpose was to find out the effect of the
cooling rate in crystallization and of homogenization of cast metal. The
investigation presents a part of work on melting and working alfenol that
has been done at the Institut pretsizionnykh splavov TsNIIChM (Institute of
Precision Alloys of TsNIIChM); the metallographic investigation has been
done by the Moscow Steel Institute. The alloy has been melted from armco
iron and A5000 (AV000) aluminum, with 16.3% Al and below 0.02% C, in an

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Metallographic investigation...

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open induction furnace, with the use of boric lime ("borkal'k") and cryolite slag. The cooling rate was varied by teeming into water-cooled copper ingot molds, steel, and ceramic ingot molds, in 2.5-4 kg ingots. Cast metal was homogenized at 1100 and 980°C, then forged and rolled hot and warm (600°C) into 0.35 mm thick strip. The investigation consisted in chemical analysis, macroscopic and microscopic analysis with quantitative metallography methods and an electronic microscope; hardness (Rockwell), microhardness, micro-thermo-e.m.f. and electric resistance were measured. Segregation of aluminum was very high (2-4%, and even 6% in one ingot); hardness varied between 8 and 13.5 R_B in one ingot. The alloy proved extraordinarily sensitive to cooling conditions; the worst porosity, deepest shrinkage holes and hetero-geneity of grain was obtained in ceramic molds. Best results were obtained in water-cooled copper molds, but with high stresses that caused deeper cracks and folds in rolled strip. Homogenization in 1100°C for 48 hrs drastically increased grain size, with smaller grain in the ingot bottom, and fine grain around the shrinkage hole (apparently due to impurities); homogenization in 980" increased grain size only slightly, slightly affected

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hardness and reduced electric resistance. Cast, homogenized and forged alloy had a peculiar network of parallel intercrossing lines in macrosections, visible even with the naked eye (Fig.3,a). The network was not present on the ground surface. After deep etching, regrinding and repeated etching, the metal crumbled in triangular and rectangular pieces. Several different network types were stated (Fig.3, a,b,c,d). The nature of the network has yet to be studied. The microscopic structure contained different phases. /Abstracter's note: The description of crystalline structure is given with references to 10 English and German language sources/. It is said that the nature of the revealed phases needs further study. The pre-sence of Fe-Al carbide and aluminum nitride is supposed, and it is concluded that alfenol melted in open furnace must be considered belonging to ternary Fe - Al - C, or to quaternary Fe - Al - C - N system. It is stressed that the presence of large carbides and nitrides on the boundaries and within grains may cause brittleness and probably causes anomalous grain growth at high temperatures. N.P.Gromov, Y.A.Gratsianov, A.A.Gerasimenko, B.V.Molo-tilov and V.A.Fedorov of the Institute of Precision Alloys carried out the investigation at the institute. Graduate of the Chair of Metallography

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Ye.M.Strug carried out the microthermo-e.m.f. measurements. There are 4
figures and 17 references: 3 Soviet-bloc and 14 non-Soviet-bloc.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: 16 April 1960

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20254

18930 1454 1045 1418

S/148/60/000/011/011/015
A161/A030

AUTHORS: Zakharov, Ye. K., Livshits, B. G.

TITLE: Investigation of transformations in the cobalt-chromium-
              -titanium system

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya
              no. 11, 1960, 105 - 112

TEXT: The work is the continuation of a study of the Co-Cr-Ti equi-
librium diagram; solid state equilibrium data determinded at 1050, 950 and
750°C (Ref. 1: B. G. Livshits, Ya. D. Khorin. Zhurnal neorganicheskoy
khimii, v. 3, no. 3, 1958; Ref. 2: P. I. Kripyakevich, Ya. D. Khorin.
Nauchnyye doklady vysshey shkoly. Metallurgiya, 1958, No.1) had to be com-
plemented. The platinum-platinorhodium thermocouple in an aluminum oxide
hood used in this experiment series had a high degree of accuracy. The
allotropic transformation was investigated by dilatometric and magnetic
methods; the Curie points were determined at the same time. The cobalt
alloys under study contained up to 60% Cr and up to 35 % Ti. The experi-
ment results are shown in the diagram (Figure 1) that includes a new phase.

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ϵ, revealed beyond the Ti solubility limit in alpha and beta Co. This intermetallic compound seemed to have a structure resembling the Ni_2Ti compound described in (Ref 10: F. Laves, H. J. Wallbaum. Zschr.f.Kristallographie v.101, 1939, p. 78, and Ref. 11: A. Taylor, R. W. Floyd. Acta cristallographica, 1950, 3, No. 4, p. 285) and CO_3Mc and Co_3W found by M. M. Babich, Ye. N. Kislyakova and Ya. S. Umanskiy in 1938 (Ref. 12: ZhTF, 1938 No. 2. v. 8). A ternary intermetallic compound was revealed also in the ternary system, Co_4Cr_2Ti (or χ-phase) (Ref. 1), and it had to be determined if it was a stable chemical compound or not. The information includes the diagrams prepared in experiments and a detailed discussion of observations. The χ-phase proved unstable and was formed by peritetic reaction in 1150 - - 1200°. The two-phase state revealed at the end of crystallization separated into two three-phase $[\epsilon + \chi + ?, \epsilon + \lambda + (Co, Cr)_2Ti]$ and two two-phase states $[\beta + \epsilon, \epsilon + (Co, Cr)_2Ti]$. The stated effect of Cr and Ti on the temperature of magnetic (θ) and allotropic (A_c and A_r) transformations is shown in four graphs (Figure 4). Alloys adjoining the Co-Ti side of the composition triangle in Co - ϵ interval and containing 15 - 20 % Cr include a component analogous with the binary quasi-eutectoid α-$Co + \epsilon$. With a higher Cr content in ternary alloys, no decomposition was observed; Cr

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Investigation of transformation in ...

additions raised the α-Co $\rightleftarrows$ β-Co transformation temperature. The allotropic $\delta \rightarrow \sigma$ transformation observed in Co-Cr alloys in 1310 - 1260° (45 - 58 % Cr) was observed in ternary alloys as well. The thermic stop in 1280 - - 1270° stated in alloys 60 % Cr - Co_2Ti and 55 % Cr - Co_2Ti at addition of 6 % Ti corresponds with the allotropic $\delta \rightarrow \sigma$ transition. Magnetic transformation occurred both above and below the A_c point, i.e., in the alpha and in the beta phase. This indicates that solid state equilibrium is difficult to reach in temperatures below 600°. There are 4 figures and 13 references: 6 Soviet and 7 non-Soviet bloc. Two English language publications read as follows: (Ref. 8) A. Elsea, A. Westermann, C. Manning, Metals Technology, 15, No. 4, 1948, 13 - 24; (Ref. 11) A. Taylor, R. W. Floyd, Acta cristallographica, 1950, 3, No. 4, p. 285.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: March 29, 1960.

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LIVSHITS, B.G.

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S/126/60/010/02/014/020
E111/E352

AUTHOR: Livshits, B.G.

TITLE: Solid-solution Heterogeneity and the Initial Stage of
          Ageing in Iron Alloys

PERIODICAL: Fizika metallov i metallovedeniye, 1960, Vol. 10,
               No. 2, pp. 272 - 284

TEXT: The author deals with the K-state (so called by Thomas,
Ref. 1) of single-phase alloys. This is characterized by changes
in many properties (Refs. 1-5). The author presents data showing
that the same considerations apply to iron-nickel alloy (36% Ni)
containing 5.5% niobium. He shows the electrical resistivity of
this alloy as functions of tempering temperature (300 - 650 °C)
for 1-50 hours' holding time (Fig. 1); all the curves show a
maximum, the resistivity also rises with increasing holding time
but this effect decreases with rising temperature. Dilatometric
and microhardness measurements confirmed the resistivity indi-
cations of the K-state. The behaviour of the alloy suggested anal-
ogy with the two stages of ageing in aluminium alloy. To check
this the author, in collaboration with Van Zhun', studied the
ageing of the alloy and type N36KhT alloy, after hardening from
1150 °C in water. Fig. 2 shows the resistivity, Fig. 3 the
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Solid-solution Heterogeneity and the Initial Stage of Ageing in
Iron Alloys

saturation magnetization and Fig. 4 the hardness as functions of
tempering temperature (100 - 900 $^{\circ}$C) for tempering times of
0.5 - 7 hours; two stages of ageing are evident in each figure.
In the high-temperature stage precipitation of second phase was
detected metallographically. No evidence of second phase was
found for the low-temperature (up to 600 $^{\circ}$C) stage. The low- and
high-temperature stages involve opposite changes in saturation
magnetization. X-ray diffraction analysis shows that the small
decrease in lattice spacing at 300 - 450 $^{\circ}$C is due to K-state
formation; the increase at 450 - 600 $^{\circ}$C corresponds to its
elimination; that at 600 - 800 $^{\circ}$C indicates a sudden change in
solid-solution concentration through precipitation of second phase.
The author estimates the activation energies for the low- and high-
temperature ageing processes at 40 000 cal/g atom and 71 000 cal/g
atom. Reversion after ageing was studied at 350 - 600 $^{\circ}$C,
followed by 5 seconds in molten tin at 700 $^{\circ}$C. Fig. 5 shows
resistivity, saturation magnetization and hardness as functions of
time for the various parts of the heat treatment. The investigation
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Solid-solution Heterogeneity and the Initial Stage of Ageing
in Iron Alloys

showed that K-state formation and precipitation of the second
phase develop independently and can, at certain temperatures,
proceed together; complete reversion is only possible before
the new phase precipitates. The author notes that similar
effects were obtained for N36KhT alloy (Ref 9) and describes
experiments with this alloy (34.5% Ni, 12.43% Cr, 3.62% Ti,
remainder Fe). Fig. 6 shows resistivity as functions of temp-
erature (300 - 800 °C) for various ageing times (0.5 - 6 hrs).
To elucidate the nature of the low-temperature stage the
influence of cold deformation on the properties of low-
temperature aged alloys was studied; Fig. 7 shows resistivity
and hardness as functions of deformation. It appears that in
this alloy, the K-state is produced by tempering below 500 °C
and destroyed by deformation. Incomplete restoration of the
alloy properties occurred after ageing at 400, 450 and 500 °C,
with brief heating to 700 °C; Fig. 8 gives the resistivity
and hardness as functions of ageing time at 450 °C (n.b. given
as 500 °C in text, 450 °C in figure caption). Similar results

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Solid-solution Heterogeneity and the Initial Stage of Ageing in Iron Alloys

were obtained dilatometrically (Fig. 9 gives length-change as functions of time for various isothermal holding temperatures). The author also reports experiments with Fe-Mo (21 and 13% Mo) and Fe-W (16 and 9% W). Results (magnetization and coercive force, resistivity and hardness) for the 21% Mo alloy are shown in Fig. 10 as functions of tempering temperature. He gives results for some further alloys (compositions in Tables 1-2). The general conclusion of the author is that the K-state is analogous to the structural state of a supersaturated solution with Guinier-Preston zones, that such zones can occur in unsaturated solutions and that they do not act as nuclei for precipitating phases. There are 10 figures, 2 tables and 18 references: 9 Soviet, 4 English, 4 German and 1 Japanese (in English).

ASSOCIATION: Moskovskiy institut stali im. I.V. Stalina
              (Moscow Institute of Steel im. I.V. Stalin)

SUBMITTED: February 6, 1960
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S/148/61/000/001/010/015
A161/A133

18. 1141

AUTHORS: Livshits, B. G., and Rymashevskiy, G. A.

TITLE: Characteristic temperature of Ni$_3$Fe + molybdenum alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya,
no. 1, 1961, 151 - 157

TEXT: The Moscow Steel Institute conducted the subject investigation
in view of different opinions in literature on the nature of transformations
in permalloys alloyed with more than 1% Mo. The composition of the studied
alloys is given in the table (in weight % of components):

Composition no.	Mo	Fe	Ni	C	Mo (atomic %)
1	-	Traces	76.0	0.032	--
2	1.2	"	76.0	0.032	0.73
3	3.2	"	76.0	0.036	1.96
4	5.2	"	76.0	0.036	3.22
5	7.2	"	76.0	0.023	4.49
6	10.2	"	76.0	0.023	6.45

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The alloys were smelted in a 10-kg capacity induction furnace, hot forged and drawn into 5 mm diameter specimens. Specific electric resistance, Young modulus, modulus of shear, and the characteristical Debye temperature were measured. The elasticity modulus and Debye temperature were determined by measuring the natural frequency of longitudinal and torsional oscillations of specimens gripped in the center and subjected either to alternating compression or to alternating torque by transmitters of corresponding design described by V. I. Korotkov [Ref. 9: ФМ и М (FM i M) v. II, no. 1, 1956 . The Young modulus (E) and shear modulus (G) were calculated by the formulae

$$E = \frac{4L^2 \rho f_1^2}{981 \cdot 10^5} \text{ kg/mm}^2 \qquad (1)$$

$$G = \frac{4L^2 \rho f_t^2}{981 \cdot 10^5} \text{ kg/mm}^2 \qquad (2)$$

where L is the specimen length; ρ - density; f_1 - natural frequency of longitudinal oscillations; f_t - natural frequency of torsional oscillations. The elasticity modulus was determined with about 0.4% accuracy. The char-

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Characteristic temperature of...

acteristical Debye temperature was also calculated from the natural frequencies of longitudinal and torsional oscillations, by a method suggested by B. N. Finkel'shteyn and V. I. Korotkov (Ref. 10: DAN SSSR, no. 5, v. 108, 1956, 846). The formula for calculating the characteristical temperature is

$$\theta = \frac{h}{k}\left(\frac{3N_A}{4\pi A}\right)^{1/3}\cdot 2 \cdot L f_t \cdot \left\{ \frac{3\gamma}{2 + \left[\frac{3 - \left(\frac{f_l}{f_t}\right)}{4 - \left(\frac{f_l}{f_t}\right)}\right]^{1/3}} \right\}^{1/3}$$

and the accuracy of θ determination is about 0.4%. All alloys were brought into an initially disordered state by quenching at 1,000°C in a 10-% aqueous solution of NaCl. Then the quenched alloys were tempered at 380° with 20 to 620 min soaking. The compound states were fixed by quenching in water. All properties were measured at room temperature. Measurements were also made on alloys in the cold-deformed state, with about 40% deformation, for comparison. All alloys were monophase solid solutions. The investigation results are given in graphs. As can be seen (Fig. 1) the Young modulus (E)

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Characteristic temperature of...

and shear modulus (G) changed in an opposite sense, G slightly dropped, and E slowly increased. The increase of the Young modulus became considerable at high Mo contents. The Young modulus and characteristical temperature (θ) change were also opposite: θ decreased with an increasing Mo content from 450°K for Ni_3Fe to 443°K for alloys with 10% Mo in the quenched state. This difference was higher after tempering: 459°K for Ni_3Fe and 446°K for alloy with 10% Mo. The electric resistance varied as shown in (Fig. 4), and the Young modulus, shear modulus and characteristical temperature as in (Fig. 5). The electric resistance behavior indicates the existence of two processes in Ni_3Fe + Mo alloy that are leading to opposite variations of resistance, and the same is apparent in (Fig. 5). An addition of Mo to binary alloys results in a drop of the adhesion power at the beginning due to the disordering effect of Mo, but this process is reversed beginning with 1% Mo. Ordering seems to start with the formation of a new ordering phase which increases with tempering. As the ordering process in Ni_3Fe causes a reduction of volume, and the atomic diameter of Mo is 12% larger than of Ni, it may be supposed that Mo atoms are getting displaced to the outside of the antiphase domains, segregate there and limit the spread of domains. Thus,

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the two different processes in Ni_3Fe+Mo during tempering are apparently the
ordering and the segregation of Mo atoms (K-state). The maximum in all
curves indicates that ordering takes place in Ni-Fe-Mo alloys at any Mo con-
tent. A comparison of data with the data obtained by A. Z. Ivanushkina
(her dissertation for the degree of Candidate of Technical Sciences, Moscow
Steel Institute, 1956) who studied the effect of the Mo-content on the
electric resistance in Invar, but it seems that the much weaker effect of
Mo in this case can be explained by the many times weaker ordering process
in invar. There are 6 figures and 10 references: 5 Soviet-bloc and 5 non-
Soviet-bloc. Two references to English-language publications read as fol-
lows: I. Nix, L. Beyer, B. Danning. Phys. Rev., 58, 1031, 1940; R. M.
Boothby, R. Bosorth, J. Appl. Phys., 18, 173, 1947.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: March 2, 1960

Card 5/8

18 1285

18 8200

AUTHORS: Verigina, Z. S., and Livshits, B. G.

TITLE: Determining the mechanical properties of the ВТ-3 (VT-3) and
ВТ-3-1 (VT-3-1) alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya,
no. 1, 1961, 170 - 175

TEXT: Two industrial heats of ВТ-3 (VT-3) and ВТ-3-1 alloys have been
investigated. Their chemical composition (in %) was:

	Ti	Al	Cr	Mo	O_2	N_2	Si	Fe	H_2	C
VT-3	Base	4.87	2.86	--	0.20	0.165	0.04	0.27	0.005	0.03
VT-3-1	Base	4.54	2.11	1.7	0.2	0.053	0.14	0.27	0.003	0.057

The investigation purpose was: 1) To determine the mechanical properties
(in tension and impact tests) after annealing to practically full equilib-
rium state;   2) To demonstrate that the mechanical properties are not chang-
ing during heating to the eutectic temperature if the specimens had been
annealed to equilibrium state;   3) To show that the standard industrial heat

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treatment rules result in a residual supercooled β-phase, and that the al-
loy containing residual high-temperature β becomes brittle in heating, i.e.
that the impact resistance is lowered. The standard heat treatment specifi-
cation requires: heating at 870°C, cooling in the furnace down to 650° and
soaking for 1 hour at this temperature, then cooling in open air. The ar-
ticle includes two tables giving the mechanical properties found in both al-
loys in the tests after the standard heat treatment, and after annealing to
practically equilibrium state. Specimens that had been so annealed had the
strength required by the standard specifications, and their impact resist-
ance corresponded to the upper standard requirement limit. Thus, alloys an-
nealed to practical equilibrium had good strength and high impact resistance
despite the very slow cooling used in the experiments (40 and 15°/hr). This
is supposed to be due to impurities (O_2, N_2) dissolved in annealing at high
temperature (in β-range) and then retained in α, despite very slow cooling.
Specific electric resistance increased at higher hardening temperatures in
the β-range, but hardness rose only slightly. At higher heating for harden-
ing, the impurities (O_2, N_2) dissolve in the β-phase, and they are alloying
elements. Higher-alloyed β yields martensite with higher electric resist-

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Determining the mechanical properties of...

ance and higher hardness, but the hardness is compensated by a higher quan-
tity of residual soft β, and this accounts for only a slight increase in
hardness comparing to the increase in electric resistance. A special in-
vestigation is necessary to study the kinetics of martenaite decomposition
and transformation of residual β during tempering, but it is apparent that
alloying elements are better utilized at higher heating temperature for
hardening and annealing. It is pointed out that tensile test specimens an-
nealed as prescribed by standard heat treatment specification developed a
clearly expressed neck, and they elongated mainly on account of the neck.
Specimens annealed to practical equilibrium stretched over nearly their en-
tire length, without any neck. It had been stated by the authors previously
(Ref. 1: Livshits and Verigina. Izv. vyssh. uch. zav. Chernaya metallurgiya,
no. 5, 1960) that the studied alloys in the equilibrium state consist of an
-phase and TiCr₂, and after annealing as per standard specifications they
contain a residual β-phase. As the quantity of slip planes in the hexagonal
α-phase lattice is smaller than in the cubic body-centered β-phase, the de-
formation of tension test specimens is different. Specimens annealed to
practical equilibrium do not become brittle when heated to temperatures be-
low the eutectic. The lower boundary of the eutectic range for VT 5-1 alloy

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A161/A133

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is at 500±10°C. In annealing as per standard specification the impact re-
sistance of specimens drops after soaking in 400, 450, 500 and 550°. Con-
clusions: 1) Annealing to practical equilibrium state yields a strength
within the standard requirements and a high impact resistance. 2) The
mechanical properties of the alloys after annealing to equilibrium do not
change after heating to eutectic temperature. Thus, the working temperature
of the alloys can be raised by producing alloys with higher eutectic temper-
ature.   3) Annealing as required in standard specifications raises strength
to the upper limit (of standard requirement range) and yields high impact
resistance; after heating to 400 - 550° the impact resistance drops. Em-
brittlement is apparently caused by the formation of the martensite phases
during the decomposition of the residual β-phase. There are 3 figures, 2
tables, and 1 Soviet-bloc reference.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: June 21, 1960

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27241

18.1250   1413 1416 1555 2813

S/148/61/000/003/013/015
A161/A133

AUTHORS: Livshits, B. G., Rymashevskiy, G. A.

TITLE: Variation of the bond forces of solid solutions in the Ni - Co - V system

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya, no. 3, 1961, 154 - 160

TEXT: Detailed information is given on the techniques and data of an investigation conducted for the purpose of contributing additional facts necessary to obtain high-strength alloys. The characteristical temperature (θ) of the alloys was determined by variations of the elasticity modulus, and an assembly was constructed to determine the Young's modulus (E) and the modulus of elasticity in shear (G) by the method of Ostroumov and Korotkov (Ref. 3,4: B. Ostroumov and L. Polotovskiy, Vestnik metallopromyshlennosti, 1933, 5, 14; V. I. Korotkov, Fizika metallov i metallovedeniye, t. II, vyp. 1, 1955). The electric resistance, hardness, density, the Curie point (T_c) (by the Akulov anisometer) were measured. The metal properties were studied on specimens after annealing at 1,200°C with 2 h holding, and after quenching from 1,200°C with 2 h holding. Binary Ni-V and ternary Ni-Co + V alloys were melted in argon in a high-frequency furnace and poured

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in argon into a copper ingot mold producing 600 - 800 g ingots. The composition
of the studied alloys was the following:

No.	V % (weight)	Co, % (weight)	Ni, % (weight)	No.	V, % (weight)	Co, % (weight)	Ni, % (weight)
1	0.81	-	Traces	6	0.9	49.81	49.29
2	1.91	-	"	7	2.21	49.91	47.88
3	3.75	-	"	8	3.86	48.31	47.83
4	8.33	-	"	9	8.55	46.19	45.26
5	11.47	-	"	10	-	51.0	51.0

The article includes the formulae used for the determination of E, G and Θ, and
references to obtained data by Broom and Barret (Ref. 6: Acta Metallurgica, 1953,
v. 1, no. 3, May, p 305) and Köster (Ref. 7: W. Köster, F. Sperner, Z.f. Metall-
kunde, 48, no. 1o, 1957). Phenomena were observed as listed in the following.
The property curves of Ni-V in the quenched and annealed state, and Ni - Co - V

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in the quenched state show monotonous variation with a changing composition; E and G, and electric resistance are growing with a raising V content. The resitance curve of Ni - V alloys has a bend at the Curie point, and of Ni-Co-V a maximum - it has a higher electric resistance when cooled to room temperature. A peculiar variation of the elasticity modulus and Poisson factor is seen in annealed Ni-Co-V alloys. Generally, it is obvious that the properties of the Ni-Co alloy are changing as this would be expected in an ordering alloy. Addition of a third element with a large atomic radius to a binary ordering alloy, i.e., Ni_3Fe + Mo, is known to replace the ordering process by a peculiar state of heterogeneous solid solution ("K-state"), and same was seen in Ni-Co-V alloys. An addition of only 1% (atomic) V to Ni-Co inverted the sense of the effect on electric resistance. At 2.5% (at) V, the resistance of the annealed alloy was higher than that of the hardened. Further raise of V content slightly reduced the resistance increase rate in annealing. In other words, alloys with above 1% (atomic) V had the K-state. An increased V content in Ni-Co-V alloys also caused an increase of the Young's modulus in the annealed state compared with the hardened one; a maximum E increase was stated at 2.54% (atomic) V content, and reached 15%; an increasing V content in Ni-Co-V alloys reduced the modulus of the elasticity in shear in the annealed stated compared with the hardened one, the maximum effect was observed in an alloy with 2.54% (atomic) V

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and reached 6%. The characteristic temperature increases during the ordering of the binary Ni-Co alloy, and an addition of V to the binary alloy reduces the bond forces increase. At 4.4 and 9.7% (atomic) V the characteristic temperature is practically same in hardened and annealed alloys. The Poisson factor practically does not change during the ordering of Ni-Co binary alloys, but grows when V is added, and reaches the maximum at 2.54% (atomic) V, i.e., in an alloy in which the electric resistance, the Young's modulus and elasticity modulus in shear attain also the maximum value. There are 4 figures and 11 references: 8 Soviet-bloc, and 3 non-Soviet-bloc. The two references to English-language publications read as follows: T. Broom and C. S. Barret. Acta Metallurgica, v. 1, no. 3, May, p. 305; N. W. Lord. Journ. Chem. Phys., 21, 692, 1953.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: November 4, 1959

Card 4/4

18.7590

28868
S/180/61/000/004/006/020
E111/E380

AUTHORS: Belyakov, L.N., Lifshits, B.G. and Potak, Ya.M.
             (Moscow)

TITLE: The role of delta-ferrite in the martensite transfor-
             mation of stainless steels

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye
             tekhnicheskikh nauk. Metallurgiya i toplivo.
             no. 4, 1961, pp. 33 - 55

TEXT: The presence of delta-ferrite in stainless steels
has, in some cases, an important effect on the martensite
transformation, shifting it towards higher temperatures
(Ref. 1 - K.J. Irvine, D.T. Llewellyn, F.B. Pickering - J. Iron
and Steel Inst., 1959, v. 192, No. 3 (Problemy sovremennoy
metallurgii, 1960, No. 3)) but, in other instances, the effect
is absent. The present investigation aimed at elucidating this
problem. Steels from three heats were used; each heat was
teemed in 5-10 batches. Individual batches differed in the
cobalt or aluminium content. The delta ferrite was isolated
from one heat (0.056% C, 0.58 Mn, 0.28 Si, 18.50 Cr, 7.60 Ni,
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0.14-1.90 Al in the different batches) by anodic solution
in an electrolyte containing 350 g/litre $FeCl_3$ and 20 ml./litre
of HCl [Abstractor's note – the text gives "20 mm/litre]. The
delta-ferrite was subjected to microchemical analysis. Since
martensite and carbides were absent after quenching from 1 050 ^{o}C,
the austenite composition could be calculated. The influence of
delta-ferrite on the martensite transformation was studied on
two other heats, whose composition (respectively, 0.06, 0.09% C;
0.53, 0.54 Mn; 0.28, 0.42 Si; 16.88, 15.20 Cr; 2.69, 4.60 Ni;
0-11.12, 0 Co; 0, 0-2.32 Al) was chosen so as to give martensite
points above room temperature in each batch. Various quenching
temperatures were used and the effect of aluminium, cobalt and
delta-phase content on the martensite transformation was studied.
The authors conclude that delta-ferrite appearing in the
structure of stainless steel produces a substantial redistri-
bution of carbon and alloying elements between delta-ferrite
and austenite, leading to a drop in martensite-transformation
temperature, the drop increasing with increasing delta-ferrite

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                                     E111/E380

content. The experiments proved that in the absence of
carbides, small quantities of delta-ferrite lead either to a
slight increase in the martensite-point temperature or to a
decrease smaller than calculated. Further experiments are needed
to elucidate this effect. Delta ferrite leads to a considerable
increase in transformation temperature after heating that results
in carbide formation. This is explained by a more intensive
separation of the carbide phase at the delta-ferrite/austenite
boundaries compared with that at austenite/austenite boundaries.
There are 2 figures, 5 tables and 7 references: 2 Soviet-bloc
and 5 non-Soviet-bloc. The four latest English-language
references quoted are: Ref. 1 - quoted in text: Ref. 2 -
F.C. Monkman, F.B. Cuff and N.J. Grant - Metal Progr., 1957,
v. 71, no. 4; Ref. 3 - H.T. Shirley - J. Iron and Steel Inst.,
1957, v. 174, no. 3; Ref. 5 - H.C. Vacher, C.J. Bechtoldt -
J. Res. Nat. Bur. Standards, 1954, v. 53, no. 2.

SUBMITTED: February 27, 1961.

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S/180/61/000/005/014/018
E071/E435

AUTHORS: Belyakov, L.N. and Livshits, B.G. (Moscow)

TITLE: Delta ferrite in an austenite-ferrite stainless steel

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye
            tekhnicheskikh nauk. Metallurgiya i toplivo, no.5,
            1961, 90-95

TEXT: The influence of hot plastic deformation (forging and
rolling) the retention time at temperatures of homogenization
(1050 to 1300°C) and cooling velocity of ingots on the amount of
δ-ferrite in an austenite-ferrite stainless steel (C 0.07 to 0.09;
Mn 0.44 to 0.70; Si 0.52 to 0.70; Cr 14.53 to 15.73;
Ni 7.7 to 8.8; Mo 1.60 to 2.30; Al 1.30 to 1.38) were
investigated.   The determination of δ-ferrite was done in all
cases by the metallographic method with an accuracy of ± 0.5 abs.%
and by the magnetic method with a relative accuracy of ± 3%.
For the latter method, specimens were austenized at 1050°C for
15 minutes, cooled in air to 300 - 250°C and annealed at 250°C for
1 hour in order to stabilize the austenite.   It was found that
the velocity of cooling of the ingots has an influence on the
amount of δ-ferrite i the austenite-ferrite steel.   The lower

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Delta ferrite in an austenite- ...   S/180/61/000/005/014/018
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the cooling rate in the range of crystallization temperatures, the
higher is the content of δ-ferrite in the cast steel. In the
axial part of the ingots weighing 25 and 450 kg the amount of
δ-ferrite is 1.35 times higher than on the periphery. On the
periphery of the ingots, martensite is present in a considerably
smaller amount than in the axial part. Hot plastic deformation
of stainless steel at 1000 to 1100°C lowers substantially the
amount of δ-ferrite, whereupon forging and rolling produce
equivalent results. A non-uniform distribution of martensite is
more stable, but this non-uniformity of the structure is removed
on rolling a 450 kg ingot into plates 6 to 2.3 mm thick. On
heating cast and forged steel to 1050 to 1150°C and retaining it
at this temperature for 0.5 to 5 hours, the amount of δ-ferrite
changes only a little, whilst at 1200 to 1300°C, it increases
substantially. Hot plastic deformation at 1000 to 1100°C lowers
the amount of δ-ferrite considerably faster than annealing at the
same temperature. It is considered that the non-uniformity of the
distribution of δ-ferrite and martensite in ingots is due to
dendritic segregation, since zonal non-uniformity along the cross-
section of an ingot is insignificant. There are 5 figures,
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5 2600

18 8200

AUTHORS;   Livshits, B.G., Rymashevskiy, G.A., and Kosyreva, N.P.

TITLE: Study of bonding forces in alloys of the
             nichrome type

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy,
             Chernaya metallurgiya, 1961, No.5, pp. 139-146

TEXT: It has been shown that some alloys with a single-phase
solid-solution structure based on transition-group metals show an
anomalous change in electrical resistivity during tempering after
hardening or cold deformation. The significance of the K-state in
alloy properties has been investigated (e.g. Ref.6; Sh.Sh. Ibragi-
mov, B.G. Livshits, FM i M V.4, 1957, No.2, 315) and ordering
effects were considered by Yu.A. Bagaryatskiy and Yi.D. Tyapkin
(Ref.10; DAN SSSR, 1958, V.122, No.5, 806). The available data,
obtained by X-ray methods, on bonding-force changes in tempering
of Ni-Cr alloys (Ref.8; V.A. Il'ina, V.K. Kritskaya et al., FM
i M., V.4, No.3, 1957, 417) are qualitative in character. The
present authors therefore decided to measure bonding forces in such
alloys by measuring their Debye characteristic temperature from the

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E111/E180

elastic moduli. The composition of alloys studied approximated
that of Ni_2Cr (see Table 1). Alloys were melted in a 5-kg high-
frequency furnace and remelted in vacuum. Ingots were poured into
a chill-mould, annealed in argon and hot-forged to a diameter of
8 mm. Test specimens were prepared by cutting. Changes in
Young's modulus, shear modulus, Debye characteristic temperature,
electrical resistivity and microstructure were studied. The
elastic moduli and characteristic temperature were determined by a
published method (Ref.11: V.I. Korotkov. FM i M. 1956, V.2, No.1
and Ref.12: V.I. Korotkov, B.N. Finkel shteyn. DAN SSSR, V.108,
No.5, 846, 1956) to an accuracy of $\pm$ 0.44%. The natural vibration
frequency was determined by comparison with the standard frequency
of a quartz generator. Hardened specimens were tempered at 300,
400 450, 500, 550, 600, 650 and 700 °C with holding times of
35 min, 1, 4, 10 and 25 hours, and then water quenched. Properties
were measured at room temperature after each heat treatment. The
changes (as percentages of the values in the hardened state) in
resistivity (ρ), shear modulus (G) and Young's modulus (E) are
shown as functions of duration (hours) in Fig.1 (subscript $3\alpha K$
means "hardened") for various tempering temperatures (300 to 700°C)
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Study of bonding forces in alloys.... S/148/61/000/005/009/015
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E111/E180

for an alloy with 31.18 atomic % Cr. The corresponding values for
tempering at 450 °C for 25 hours are shown as functions of Cr
content in Fig. 4 (which also includes the percentage change of θ,
the Debye characteristic temperature). The observed change in θ
is much less than reported in the literature for similar alloys.
The indications are that the relation between the characteristic
temperature (as determined by X-ray investigations) and the value
of the atomic interaction force is more complex for alloys than for
pure metals. As pointed out by V.I. Iveronova, O.N. Kassandrova
and Ye.G. Rozantseva (Ref. 14; same journal, 1960 No.1, 133) the
distribution as well as the maximum vibration frequency is involved
and this distribution probably changes on passing from pure metal
to solid solutions. The development of the K-state on tempering
is accompanied by a volume decrease in all tested alloys,
producing a characteristic microstructure and leading to an
increase in bonding force; A.S. Kagan and Ya.S. Umanskiy made an
analogous assumption. The closer the alloy composition is to
Ni_2Cr the greater the increase. From their own and other work the
authors consider the direct relation between the K-state and local
ordering in Ni_2Cr type nichrome alloys (proposed by
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Study of bonding forces in alloys....   S/148/61/000/005/009/015
                            23995
                            E111/E130

Yu.A. Bagaryatskiy and Yu.D. Tyapkin in Ref. 10) to be sufficiently conclusively proved. The question of whether this physical heterogeneity is accompanied by chemical (atomic) segregation in alloys with less than 33 atomic % Cr remains unanswered. There are 7 figures, 2 tables and 15 references: 9 Soviet, 3 English and 3 German. The English language references read: Ref. 1: Ziro Jano. Japan Nickel Rev., 9, 17, 1941. Ref. 3: A. Taylor, K.G. Hinton, J. Inst. of Metals, 81, 169, 1952. Ref. 5: R. Nordheim, N. Grant. J. Inst. of Metals, 82, 9, 1954.

ASSOCIATION: Moskovskiy institut stali
                  (Moscow Steel Institute)

SUBMITTED: September 29, 1960

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18 7500

AUTHORS: Verigina, Z.S., and Livshits, B.G.

TITLE: Study of the annealing of VT-3 and VT-3-1 alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy,
            Chernaya metallurgiya. 1961, No.5, pp. 162-172

TEXT: The structure and properties of titanium alloys were
studied, in connection with the decomposition of the martensitic
structure (α'-phase) and the transformation of the residual
β-phase. The Ti-base alloys used were VT-3 (4.87%Al, 2.86 Cr,
0.2 O_2, 0.165 N_2, 0.04 Si, 0.27 Fe, 0.003 H_2, 0.03 C), and VT-3-1
(4.54% Al, 2.11 Cr, 1.7 Mo, 0.20 O_2, 0.053 N_2, 0.14 Si, 0.27 Fe,
0.003 H_2, 0.057 C).   The VT-3 alloy was quenched from 1100 and
1200 °C in water, and annealed at 100-800 °C with water or air
cooling. Electrical resistance and hardness measurements, and also
microstructural, X-ray and dilatometry studies, were made.
Fig. 1 shows the electrical resistance (ohm mm^2/m) against
tempering temperature °C (after hardening) for different times, for
the VT-3 alloy. Fig. 1a after heat treatment at 1200 °C for two
hours and quenching in water, with an air cool after tempering:
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Study of the annealing of VT-3 and... E021/E135

Fig. 16 is the same with a water quench after tempering. Fig. 16 is after heat treating at 1100 °C for 15 minutes and water quenching, with water cooling after tempering). Similar curves are plotted for hardness after the same heat treatments.

Fig. 4 shows the change in hardness (Fig. 4a) and electrical resistance (Fig. 4b) of alloy VT-3-1 against annealing temperature after heat treatment at 1000 °C for 15 minutes and water-quenching, with water cooling after annealing. (Curve 1 is annealing for 2 hours; curve 2 for 12 hours; curve 3 for 24 hours). It can be seen from the curves that the relation between the properties of the alloys and tempering temperature is somewhat complicated and depends on the initial structure after quenching. Decomposition of the martensitic phase during ageing leads to a decrease in hardness and electrical resistance and transformation of the residual β-phase leads to an increase in properties. Cooling in water after tempering accelerates the transformation of the residual β-phase. The transformation of the residual β-phase probably takes place by a martensitic change, but the temperature of the end of the transformation is in the subzero temperature range, and it is therefore impossible to obtain a structure without metastable

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Study of the annealing of VT-3 and ...   S/148/61/000/005/012/015
phases by hardening and tempering.   E021/E135
There are 5 figures, 1 table and 4 references: 3 Soviet and
1 German.

ASSOCIATION: Moskovskiy institut stali
             (Moscow Steel Institute)

SUBMITTED: October 29, 1960

Card 3/7

S/148/61/000/007/008/012
E193/E380

18.8200   1327

AUTHORS: Livshits, B.G. and Rymashevskiy, G.A.

TITLE: Elastic properties of alloys of the nickel-vanadium
          system

TEXT: Many alloys, which at high temperatures constitute
single-phase solid solutions, change their atomic structure on
cooling.   A particular group of alloys of this type is repre-
sented by alloys in which a so-called K-state, stable at low
temperatures, exists.   The onset of the K-state is revealed by
an anomalous variation of properties, particularly electrical
resistivity during annealing of quenched or work-hardened speci-
mens.   It has been postulated by Thomas (Ref. 1, Z.f. Physik,
129, 219, 1951) that the K-state is a characteristic of alloys
at least one component is a transition metal.   The validity
was to check the validity
metals, namely,

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S/148/61/000/007/008/012
E193/E380

Elastic properties ....

about 0.009% C and up to 12.98 at.% V, were prepared by HF induction melting in argon, followed by a homogenizing treatment, forging to rods 8 mm in diameter, and machining to 4.2 mm diameter. The measurements were carried out on annealed (2 hours at 1 200 °C followed by furnace-cooling) or quenched (2 hours at 1 200 °C followed by water-quenching) specimens. The results are reproduced in Fig. 1, where the electrical resistance (ρ, ohm.mm^2/m), Young's modulus (E, kg/mm^2), shear modulus (G, kg/mm^2), characteristic temperature (Θ, °K) and Poisson ratio (μ) are plotted against the vanadium content (at.%), graphs a and b relating to specimens in the quenched and annealed condition, respectively. It will be seen that no anomalies were found in the concentration-dependence of any of the properties studied and further experiments showed that the same applies to the temperature-dependence of ρ. Thus, it has been shown conclusively that the K-state does not exist in Ni-V

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S/148/61/000/007/008/012
E193/E380

Elastic properties ....

S.A. Yeliseyev, G.M. Ashmarin and B.N. Finkel'shteyn are
mentioned for their contributions in the field.
There are 3 figures and 9 references: 6 Soviet-bloc and
3 non-Soviet-bloc. The English-language references quoted
is: Ref. 8 - Z. Nishiyama. Sci. Rep., Tokio University,
18, 359, 1929.

ASSOCIATION: Moskovskiy institut stali
               (Moscow Steel Institute)

SUBMITTED: March 2, 1960

Card 3/4

AUTHORS: Lakhman, N.G., Livshits, B.G.

TITLE: Phase transformations in ЭИ14М2 (Yul4M2) alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya
            metallurgiya, no.11, 1961, 122-128

TEXT: Iron-aluminium alloys of the alphenol type (16% Al) are a
promising substitute for nickel-base high permeability alloys.
The authors have studied the properties of similar alloys (Ref.1:
Precision alloys. Sb. trudov TsNIIChM, no.23, Metallurgizdat, 1960).
Although binary Fe-Al alloys have been investigated by several
authors, little has been done on phase changes in ternary iron-
aluminium-molybdenum alloys.   For their present work, in which
A. Kshivitska participated, the authors studied an iron-aluminium
alloy with 2% molybdenum (type Yul4M2 alloy) which has good
magnetic properties.   The alloy was H.F. induction melted in a
30 kg furnace using directly-reduced iron, primary aluminium and
metallic molybdenum.   Melting was effected with diffusional
deoxidation with a lime slag, treatment with a mixture of
aluminium powder and lime and covering with a cryolite slag.   The
alloy composition was 14.8% Al, 1.97% Mo, 0.005% C,

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S/148/61/000/011/009/018
E111/E480

Phase transformations ...

0.007% S, 0.003% P, 0.01% Si, 0.001% N_2, traces of copper and no detectable Mn, Cr or Ni. The 8 kg ingots were homogenized, forged, hot-rolled to a thickness of 2 mm and rolled at 600°C to 0.35 mm thick strip. Change of electrical resistance on heating and cooling was measured using a potentiometric apparatus: specimens were heated in a tube furnace at 200°C/hour. To find the room-temperature resistance after hardening and tempering, 150 x 10 x 0.35 mm strip specimens were tested in a double Thomson bridge. The modulus of elasticity was determined on heating up to 900°C and cooling by A.V.Panov's method (Ref.8: G.A.Rymashevskiy, Izv.VUZ. Chernaya metallurgiya, no.1, 1961) on 50 x 10 x 0.35 mm specimens; the value of the resonance frequency corresponding to maximum amplitude was found at each temperature. The effect of temperature on magnetization was found with N.S.Akulov's "anisometer" apparatus using 3 mm diameter, 30 mm long specimens at heating and cooling rates of 200°C/hour. For magnetic measurements by the ballistic method, toroids of 50/40 mm diameter and 0.35 mm thickness were used. The results showed that tempering of the quenched alloy at 200 to 450°C leads

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Phase transformations ...

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E111/E480

to a decrease in electrical resistance and magnetic permeability
and an increase in coercive force as a result of an ordering
process.   Further evidence of ordering is provided by curves
showing the dependence of resistance, elastic modulus and
saturation magnetization on temperature.   Ordering intensifies
with increasing tempering time but disappears on prolonged holding.
Changes in the modulus of elasticity and electrical resistance
above 500°C are anomalous, as is the resistance increase when a
quenched alloy is tempered over 500°C.   One explanation of these
effects is in terms of the transition from a superstructure of the
type Fe_3Al to FeAl; but it is difficult to believe that
formation of the non-magnetic FeAl structure would raise the
maximum permeability by 30%: moreover, anomalous forms of
resistance curves are also observed in other alloys in which there
is no second type of structure in the high-temperature region.
It is more likely that, in the Yu14M2 alloy, two processes are
superimposed, one being ordering and the other possibly associated
with redistribution of atoms (K state); the nature of the latter
requires further investigation.   This second process is

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Phase transformations ...   S/148/61/000/011/009/018
                                             E111/E480

evidently stimulated by the introduction of molybdenum which also
retards ordering.   There are 4 figures and 19 references:
11 Soviet-bloc and 8 non-Soviet-bloc.   The references to English
language publications read as follows:
Ref.4: A.Taylor, B.Jones, J. Phys. Chem. Solids, 6, 1, 1968, 16;
Ref.10: B.D.Bennett, J. Iron and Steel Inst., 171, 1, 4, 372, 1952;
Ref.11: C. Sykes, H. Evans, Proc. Roy. Soc., 145, 529, 1934;
Ref.18: F.W.Jones, C.Sykes. Proc. Roy. Soc., A. 166, 376, 1938.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: May 3, 1961

Card 4/4

S/126/61/012/003/002/021
E021/E180

AUTHORS: Kekalo, I.B., and Livshits, B.G.

TITLE: A new magnetic-diffusion effect in invar, studied by
             the method of internal friction

PERIODICAL: Fizika metallov i metallovedeniye,   v. 12, no. 3, 1961,
             314-321

TEXT: The low temperature transformations in invar were
investigated by the method of internal friction since this method
is very sensitive to atomic diffusion processes occurring in
metals and alloys. The heating device and the sample were placed
in a solenoid which enabled measurements of internal friction at
different temperatures and in a magnetic field. The samples were
300 mm long and 0.7 mm in diameter. Measurements were carried out
in vacuo (10^{-3} to 10^{-4} mm Hg). The internal friction was
calculated from the usual formula. All the experiments were
carried out on annealed samples. Good reproducibility of results
was obtained. The basic internal friction-temperature curve for
invar containing 0.02% carbon has a peak at 200 °C caused by
diffusion of carbon atoms into the γ-lattice in a field of elastic
Card 1/2

A new magnetic-diffusion effect in ...   S/126/61/012/003/002/021
                                          E021/E180

stresses.   When the sample is held at a constant temperature below the Curie point, the internal friction falls with time, the main decrease taking place in the first 1.5 hours. The maximum decrease occurs at 100 $^{\circ}$C and is 17-20%.   At room temperature and at the Curie point (260 $^{\circ}$C) the decrease is very small.   If the sample is magnetised to saturation, internal friction does not drop with time on holding at a given temperature. The effect also depends on carbon content. The greater the carbon content, the more marked is the fall in level of internal friction.   The observed effect is attributed to segregation of carbon atoms in the boundary regions of domains.   K.P. Belov is mentioned in the paper.   There are 5 figures and 7 references: 4 Soviet-bloc, 1 Russian translation from a non-Soviet publication, and 2 non-Soviet.   The two English language references read as follows:
Ref.3: I.S. Marsh. Alloys Iron a. Nickel, I, 1938.
Ref.6: B.S. Zement, B.L. Averbach, M. Coheu. Trans. Amer. Soc.
       Met., 1951, 43, p.1072.
ASSOCIATION: Moskovskiy institut stali im. I.V. Stalina
Card 2/2   (Moscow Steel Institute imeni I.V. Stalin)
SUBMITTED: January 2, 1961

S/126/61/012/004/005/021
E111/E335

AUTHORS: Gorbunov, V.I. and Livshits, B.G.

TITLE: Investigation of the structure of irreversible alloys
             in the Fe-Co-V system. I.   Alloys with a high
             vanadium content

PERIODICAL: Fizika metallov i metallovedeniye, v. 12, no. 4,
              1961, 526 - 533

TEXT: The metastable state of iron-cobalt-vanadium alloys
has some similarities to that of iron-nickel alloys but both
metastable transformation and decomposition on isothermal holding
to form alpha and gamma phases can occur. The present work is
devoted to a study of the structure of iron-cobalt-vanadium
alloys with 9 - 15% vanadium and 52% cobalt. The structure of
the alloys was investigated in non-equilibrium states after
quenching from the single-phase gamma region followed by iso-
thermal tempering and after cooling from the same region at
20 °C/hour to room temperature and to intermediate temperatures
with subsequent water-quenching. The structure of irreversible
iron-nickel alloys (10 - 20% nickel) after quenching and
Card 1/4

Investigation of .....

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E111/E335

isothermal tempering were also studied. X-ray, dilatometric
and optical and electronic microscopic methods were used. Alloys
were high-frequency induction melted and subjected to hot and
cold deformation to obtain rods and wires for preparation of
specimens. Polished sections were prepared in the normal way;
lacquer replicas were used for electron-microscopy. X-ray
diffraction patterns were obtained in monochromatic CrKα
radiation, specimens being heat-treated in evacuated quartz
capsules. Dilatometric specimens were made from cold-rolled
5-mm diameter wire; curves were obtained at heating rates of
2 °C/min. The authors draw the following conclusions: the
structure and phase state of the iron-cobalt-vanadium alloys
greatly depend on the rate of cooling from the all-gamma
solid-solution region. If cooling rates are high (water-
quenching), the ordering and decomposition processes in the
gamma-phase are suppressed and only the martensite transformation
occurs on cooling, its extent depending on the composition.
Complete decomposition to give alpha- and gamma-phases,
according to the phase diagram, occurs with very slow cooling.

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Investigation of S/126/61/012/004/005/021
                          E111/E335

With intermediate cooling rates partial decomposition and
martensite transformation is accompanied by ordering processes
in the supercooled gamma phase having the alloy composition.
The phase state and structure also change greatly in the tempering
of quenched alloys, depending on tempering temperature and
vanadium content. Heterogeneous decomposition to form alpha and
gamma phases occurs in alloys having martensite structure in the
initial state; this is accompanied in high-vanadium alloys by
decomposition and ordering of residual austenite. There are,
thus, two composition regions, in one of which the gamma-phase
separates from alpha and, in the other, alpha from gamma.
According to this characteristic, W. Köster and H. Schmid
(Ref. 8 - Arch. Eisenhüttenw., 1955, 26, 421) subdivided the
two-phase composition region into two regions. However, the
present work has shown that the 10-12% vanadium (52% Co) alloys
have a tempered structure consisting of precipitates of gamma-
phase in alpha matrix and decomposed austenite with precipitates
of alpha-phase. Intermediate-region alloys have the highest
coacive force after quenching and tempering. The results agree
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V

Investigation of S/126/61/012/004/005/021
                                      E111/E335

with published X-ray data (Ref. 10 - R.W. Fountain, J.F. Libsch, Trans. AIME, 1953, 197, 349).
There are 6 figures, 1 table and 10 references: 4 Soviet-bloc and 6 non-Soviet-bloc. The two English-language references mentioned are: Ref. 3 - D.L. Martin and A.H. Geisler - Trans. ASM, 1952, 44, 461; Ref. 10 (quoted in text).

ASSOCIATIONS: Institut preksizionnykh splavov TsNIIChM
                 (Institute of Precision Alloys of TsNIIChM)
                 Moskovskiy institut stali im. I.V. Stalina
                 (Moscow Steel Institute im. I.V. Stalin)

SUBMITTED: October 24, 1960

Card 4/4

S/126/61/012/004/006/021
E111/E335

AUTHORS: Gorbunov, V.I. and Livshits, B.G.

TITLE: Investigation of the structure of irreversible alloys
             of the system Fe-Co-V. II. Alloys with a low vanadium
             content

PERIODICAL: Fizika metallov i metallovedeniye, v. 12, no. 4,
             1961, 534 - 540

TEXT: Following their earlier work (Ref. 1 - FMM, 1961,
11, no. 6) on high-vanadium iron-cobalt alloys with 52% cobalt,
the authors now describe a later investigation. This was on
the structure of iron alloys with 2.5 - 4.5% vanadium and
52% cobalt formed by slow cooling from the single-phase gamma
region, and on the structure of alloys with under 2% vanadium
after quenching and isothermal tempering. Various cooling rates
were used, from 1 000 °C: water-quenching, cooling with the
furnace and still more slowly at 20 °C/hour. The latter method
was also adopted for cooling alloys to 800 - 500 °C at 50 °C
intervals with subsequent water-quenching. Specimens were
quenched either directly after reaching the required temperature
Card 1/3

Investigation of ....

S/126/61/012/004/006/021
E111/E335

or after a 24-hour isothermal holding. Sometimes the structure was studied after quenching and tempering. The methods of investigation were the same as in the work described previously (Ref. 1). The authors draw the following conclusions for the 2.5 - 4.5% vanadium alloys: decomposition of supercooled gamma-phase at and below gamma/alpha boundary temperatures on the metastable phase diagram is complicated by alpha-phase decomposition. The process occurs as follows: the gamma-phase, undecomposed at high temperatures, is converted into alpha-phase of the same composition on cooling; this change is martensitic in alloys with over 4.5% vanadium but in those with less vanadium, in which the transformation temperature is high, it is diffusional. The alpha-phase produced decomposes on slow cooling or isothermal holding to give an alpha + gamma structure. Thus, two successive phase-transformations occur. Comparison of the microstructure of annealed alloys with that of alloys tempered after quenching indicates that alpha-phase decomposition in tempering and in slow cooling leads, at temperatures below the critical temperature of ordering, to the formation of a highly dispersed mixture of

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Investigation of ....

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E111/E335

ordered α'-phase and γ-phase. Only the gamma-to-alpha transformation, without composition change, occurs with increasing cooling rates. Alpha-phase decomposition also fails to occur during slow cooling in alloys with over 4.5% vanadium; this is due to its low formation temperatures. In alloys with under 2% vanadium the gamma-phase formed by decomposition of alpha during isothermal tempering changes into alpha-phase on cooling to room temperature.

There are 4 figures, 1 table and 6 references: 3 Soviet-bloc and 3 non-Soviet-bloc. The English-language reference mentioned is: Ref. 4 - D.Z. Martin, A.H. Geisler - Trans. ASM, 1952, 44, 461.

ASSOCIATIONS: Institut pretsizionnykh splavov TsNIIChM
                  (Institute of Precision Alloys of TsNIIChM)
                  Moskovskiy institut stali im. I.V. Stalina
                  (Moscow Institute of Steel im. I.V. Stalin)

SUBMITTED: October 24, 1960

Card 3/3

S/126/61/012/005/003/028
E039/E135

AUTHORS: Kekalo, I.B., and Livshits, B.G.

TITLE: On the magnetic diffusion effect in Invar,
             investigated by the internal friction method.   II.

PERIODICAL: Fizika metallov i metallovedeniye, v.12, no.5, 1961,
             644-651

TEXT: Ya.S. Shur and I.Ye. Startseva (Ref.2: ZhETF, 1960,
v.39, no.3) have shown that cyclic temperature changes cause
irreversible changes in the domain structure. In particular they
bring about thermal magnetic hysteresis. The aim of the present
paper was to investigate the thermal effects on internal friction
(Q^{-1}) in invar containing 0.26% C. The work is a continuation of
previous work by the same authors. They show that heating after
stabilising treatment restores the internal friction (Q^{-1}) to its
original value in accordance with a basic curve. This restoration
is more complete for higher rates of heating and by heating to
higher temperatures. As a consequence of heating after the
stabilisation treatment conditions are created for a new decrease

Card 1/2

AUTHORS: Kekalo, I.B. and Livshits, B.G.

TITLE: Internal friction of Invar as a function of
             temperature, carbon content, intensity of
             magnetization and time factor

PERIODICAL: Fizika metallov i metallovedeniye, v.12, no. 6,
             1961, 838 - 845

TEXT: The object of the present investigation was to study
the effect of the time factor and intensity of magnetization on
the temperature-dependence of internal friction of Invar
containing 0.01 or 0.26% C. The investigation was undertaken
because neither anomalous properties of this alloy associated
with its magnetic characteristics, nor the volume effects
associated with redistribution of the C atoms at low temperatures
were taken into account in earlier studies of this problem. The
measurements were carried out in vacuum (10^{-3} - 10^{-4} mm Hg) on
wire specimens (300 mm long, 0.7 mm in diameter), preliminarily
annealed at 800 °C for 15 minutes. The results can be

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Internal friction of S/126/61/012/006/006/023
                                             E193/E383

summarized as follows.
1) On raising the temperature to 260 - 300 $^{\circ}$C the internal-
friction background Q^{-1} of Invar rapidly decreases. Its
magnitude becomes much lower when the alloy is placed in a
magnetic field and is hardly affected by temperature variation
below the Curie point.
2) An internal-friction peak is observed at approximately
200 $^{\circ}$C. Its height increases with increasing C content and
decreases on the application of a magnetic field. In the
case of the alloy with 0.26% C, the decrease due to the appli-
cation of a field of 250 Oe amounted to 60%.
3) The carbon-induced internal-friction peak is shifted towards
higher temperatures on the application of a magnetic field, this
effect being mainly due to the displacement of the low-temperature
branch of the peak; this is illustrated by typical results,
reproduced in Fig. 6, where
$Q^{-1} \times 10^4$ of a specimen with 0.26% C is plotted against
temperature ($^{\circ}$C); Curves 1 and 2 relate to results obtained
Card 2/10

Internal friction of ....

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E193/E383

without the application of a magnetic field and in an
alternating field H = 250 Oe, respectively.
4) Increasing the vibration frequency brings about an increase
in the internal-friction background level and a displacement of
the internal-friction peak towards higher temperatures, both
these effects being independent of the presence of a magnetic
field.
5) Calculated values of the activation energy for the C atoms
were U = 34 500 ± 3 000 cal/mole at H = 0 and
U = 35 800 ± 3 000 cal/mole at H = 250 Oe .
6) The character of the temperature-dependence of internal
friction of Invar depends on the experimental conditions, two
different internal-friction curves being obtained for the region
below the Curie point, depending whether the specimen is heated
continuously or held for 2 hours at each test temperature before
taking the measurement. The effect of the time factor is
demonstrated in Fig. 7, showing a Q^{-1} versus temperature
curve for a specimen with 0.26% C; the low-temperature branch
of the curve, indicated by a broken line, relates to results

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Internal friction of ....

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E193/E383

obtained on specimens held for 2 h at the test temperature;
it will be seen that this treatment brought about a decrease
in Q^{-1}, the magnitude of this effect reaching a maximum at
approximately 90 ^{o}C.
7) The results obtained indicate that the relaxation phenomena
in ferromagnetics should be studied both with and without the
application of a magnetic field in order to distinguish between
the magnetic effects and those associated with redistribution
of atoms and structural changes.   There are 7 figures and
11 references: 8 Soviet-bloc and 3 non-Soviet-bloc.

ASSOCIATION: Moskovskiy institut stali   (Moscow Institute
               of Steel)

SUBMITTED: November 15, 1960

Card 4/4

30081
S/048/61/025/011/027/03?
B117/B102

IS·2450

AUTHORS.   Livshits, B. G., Yeliseyev, S. A., Samarin, B. A., and
Somenkov, V. A.

TITLE: Phase equilibrium in the Fe_2O_3 — BaO system

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Seriya fizicheskaya,
v. 25, no. 11, 1961, 1418-1421

TEXT: The diagram of the quasibinary phase equilibrium of the Fe_2O_3 — BaO
system was studied. The investigation involved structural analysis (by
X-ray and optical microscopy), measuring the structure-independent
(structurally insensitive) magnetic properties (saturation magnetization,
Curie point), and measuring the microhardness of the individual phase.
The specimens were prepared from Fe_2O_3 and $Ba(NO_3)_2$, and were sintered at
different temperatures. Their compositions are given in a table. The
microstructure was examined on specimens nos. 1-20 sintered at $1200^\circ C$ for
8, 24, and 32 hr, and each of them was ground and pressed after 8 hours.
The microstructure was also examined on specimens sintered at $1300^\circ C$ for

Phase equilibrium in the ...

30081
S/048/61/025/011/027/031
B117/B102

4 hr (nos. 1-9) and for 1 hr (nos. 10-12). Specimens no. 7 were found to consist of one phase, and specimens nos. 2-6 and nos. 8-20 to consist of two phases. The bright phase in no. 2-6 seemed to be hematite, whereas the dark one appeared to be barium hexaferrite $BaO \cdot 6Fe_2O_3$. The bright phase in nos. 8-20 was barium hexaferrite. The dark one could not be identified and was designated as X-phase. In almost all ferrites, the three phases showed constant hardness throughout the above-mentioned periods of time and at every sintering temperature. The saturation magnetization was examined on specimens of the quasibinary $Fe_2O_3 - BaO$ system after sintering at $1200°C$ for 6, 16, 24, and 32 hr. and by grinding them intermittently. The saturation magnetization as a function of composition, was found to have a maximum for specimen no. 7, and dropped linearly on either side of it. This shows that two phases exist in the ranges of 0-14.3% of BaO and 14.3-50% of BaO: a magnetic ($BaO \cdot 6Fe_2O_3$) and a nonmagnetic phase. It is hematite in the range mentioned first, and evidently $BaO \cdot Fe_2O_3$ in the other. The Curie temperature was measured on the same specimens. In the range of 14.3-50% of BaO the Curie point was

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χ

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S/048/61/025/011/027/031
B117/B102

Phase equilibrium in the ...

constant, which is indicative of the heterogeneity of this range. In the
range of compositions from no. 7 to 9 the Curie point is lowered, probably
due to the presence of a homogeneous region. In the range up to 14.3% of
BaO the Curie point was anomalously reduced for specimens nos. 2, 3, and
4, after 16-32 hr of sintering. This is probably a consequence of the
change in the composition or in the structure of the ferrimagnetic phase
(barium hexaferrite). In specimens nos. 2-6, which were sintered at
1200°C for 24 and 32 hr, heterogeneity was established by means of X-ray
structural analysis. The specimens sintered for 24 hr consist of
hematite and barium hexaferrite. On an increase of the BaO content in
the mixture, the hexaferrite lines become more intense, while the hematite
lines turn weaker. In specimens sintered for 32 hr it was established
that with increasing BaO content the lattice constant of barium
hexaferrite increases on axis a, and drops somewhat on axis c. Changes in
lattice parameters are quite insignificant. Still, they exceed the
experimental errors; this should not occur in the heterogeneous region of
the binary equilibrium diagram. There are 4 figures, 1 table, and
3 references: 1 Soviet and 2 non-Soviet. The reference to the English-
language publications reads as follows: Yasumasa Goto, Toshia Takada, J.

Card 3/5/4/

Phase equilibrium in the ...

Amer. Ceram. Soc., 43. 150 (1960)

30081
S/048/61/025/011/027/031
B117/B102

Table: Compositions of examined specimens
Legend. (1) no of specimen; (2) molar ratio; (3) mol% BaO.

Card 4/$\cancel{4}$

S/032/61/027/001/028/C37
B017/B054

AUTHORS: Selyavo, A. L., Livshits, B. G., and El'burikh, G. S.

TITLE: Device for Testing the Deflection of Springs on Heating

PERIODICAL: Zavodskaya laboratoriya, 1961, Vol. 27, No. 1, pp. 95-97

TEXT: A device was developed for studying the deflection of springs on
heating. The springs are subjected to a mobile load (of up to 18 kg). The
device permits both the determination of spring elasticity as a function
of load at constant temperature and the determination at different
temperatures (of up to 900°C) under constant load. The load is applied to
the springs by means of a mobile plunger. Fig. 2 shows the calibration
curves for the increase in length of an H43XT (N43KhT)-alloy plunger, and
those for the increase in length of a plunger consisting of quartz tubes.
The increase in deflection of springs on heating up to a temperature T is
calculated by the following formula: $(\Delta\lambda)_T = (\pm \ell_T) - \left| \pm (\lambda 1)_T \right|$, where

$\mathcal{E}_T$ = sum of spring deflection plus plunger elongation in mm, $(\Delta 1)_T$

= absolute amount of plunger elongation in mm. The deflection of springs

Card 1/2

Device for Testing the Deflection of Springs   S/032/61/027/001/028/037
on Heating   B017/B054

on heating of the following steel types was studied: 3X13 (3Kh13), ЭИ961
(EI 961), 50XФA(50KhFA), and 65C2BA(65S2VA). The tests were made at an
initial stress t = 10 kg/mm^2 and under constant load. Fig. 3 shows the
curves representing the dependence of increase in deflection of springs
on the heating temperature at t = 10 kg/mm^2 and P = const. There are 3
figures.

ASSOCIATION: Vsesoyuznyy institut aviatsionnykh materialov (All-Union
              Institute of Aircraft Materials)

Card 2/2

BELYAKOV, L.N.; LIVSHITS, B.G.

Phase analysis of X18H8IU austenite-ferrite steel. Zav.lab. 27
no.10:1192-1194 '61.   (MIRA 14:10)

1. Moskovskiy institut stali im. I. V. Stalina.
                        (Steel—Analysis)
                        (Austenite)
                        (Ferrite)

AUTHORS: Zakharov, Ye.K., Livshits, B.G. (Moscow)

TITLE: Phase composition diagram of cobalt-chromium-titanium
              alloys

PERIODICAL: Akademiya nauk SSSR. Izvestiya. Otdeleniye
              tekhnicheskikh nauk. Metallurgiya i toplivo,
              no.5, 1962, 143-150

TEXT: Due to numerous discrepancies in the data reported so far,
a re-examination was made of the binary Co-Ti system
(30% Ti) at temperatures up to 1500°C and a modified phase
equilibrium diagram plotted.   The Co-Cr binary phase equilibrium
diagram used in studies of the ternary system was that reported by
A.R.Elsea, A.B.Westermann and G.K.Manning (Metals Technology,
v.14, no.4, 1948, 13-24).   An analysis of the equilibrium
conditions in the Co-Cr-Ti system was followed by plotting the
liquidus and solidus curves of the Co corner of the Co-Cr-Ti
alloys and of the low and high temperature parts of the same
ternary system.   Special attention was paid to polymorphic and
magnetic transformations (Curie point) and their dependence on
temperature.   The intersection of the surface of allotropic
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Phase composition diagram ...   S/180/62/000/005/008/011
                                                 E040/E435

transformation and of the Curie point with the surface of
limited solubility was investigated by thermomagnetic and
dilatometric techniques and the results are plotted graphically
for Cr and Ti contents up to 20% by wt.   There are 5 figures.

SUBMITTED: December 23, 1961

Card 2/2

18.1000

41630
S/148/62/000/009/005/007
E071/E483

AUTHORS: Lakhman, N.C., Livshits, B.G.

TITLE: Recrystallization and grain growth in iron-aluminium-molybdenum alloys

PERICDICAL: Izvestiya vysshikh uchebnykh zavedeniy. Chernaya metallurgiya, no.9, 1962, 155-159

TEXT: Recrystallization of iron-aluminium-molybdenum alloys, containing 14% aluminium and 1, 2, 3 and 4% molybdenum was studied to obtain data on recrystallization and grain growth of these alloys necessary for choosing the optimum mechanical working and heat treatment schedules.   The alloys were prepared in an induction furnace from directly reduced iron, primary aluminium and metallic molybdenum.   The alloys were homogenized, forged, hot rolled into a strip 2 mm thick, normalized, pickled and rolled into a strip 0.35 mm thick.   The recrystallization annealings (each of 1 h duration) were carried out in vacuo at 550 to 1100°C at 50°C intervals.   The influence of heating on the grain growth was studied by two metallographic methods due to Jeffries and Saltykov.   For approximate determination of the

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Recrystallization and grain ...   S/148/62/000/009/005/007
                                              E071/E483

temperature of the beginning of recrystallization, hardness of the
specimens was measured both after annealing at 550 and 600°C and
in the as-rolled condition; the temperature of the beginning of
recrystallization of the alloys studied was found to lie between
550 and 600°C.   A sharp increase in the rate of grain growth of
all these alloys at 800 to 850°C indicated that if brittleness is
to be prevented, the annealing temperature must not exceed 800°C.
Increasing the molybdenum content to 4% slows down the grain
growth in the 850 to 950°C temperature range, probably as a result
of the precipitation of the second phase. The latter redissolves
on annealing at 1100°C; this probably explains why, after
annealing at 1100°C, the difference between the grain size of
alloys with various molybdenum contents disappears.   There are
5 figures and 1 table.

ASSOCIATION: Moskovskiy institut stali i splavov
             (Moscow Steel and Alloys Institute)

SUBMITTED: January 3, 1962

Card 2/2

37243

S/148/62/000/003/008/011
E039/E485

24,7000
18,1200
AUTHORS: Livshits, B.G., Sumin, V.I.

TITLE: Galvano- and thermomagnetic effects and bond strengths
             in α-solid solutions of Cu-Zn, Cu-Ga, Cu-Ge

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy.
            Chernaya metallurgiya, no.3, 1962, 111-121

TEXT: The solid solutions based on copper alloyed with other
elements in the same group with increasing valency (Zn, Ga, Ge)
are studied.   The electron concentration in these alloys
increases as we go from Cu-Zn to Cu-Ge.   Alloys of the following
composition were prepared from pure elements melted in a
graphite crucible under an argon atmosphere.

Cu-Zn   1.8; 8; 12; 17; 20; 24.8; 36.7 (% Zn)
Cu-Ga   2;   7; 10; 12; 16; (% Ga)
Cu-Ge   2;   4; 6; 8; (% Ge)
Cu   pure.

All the alloys formed single phase solid solutions and their
properties were studied after cold deformation, after hardening
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Galvano- and thermomagnetic ...

S/148/62/000/003/008/011
E039/E485

at 500°C and after annealing.   The method of measurement and
calculation of galvano- and thermomagnetic constants used was as
described in an earlier paper (H. Schmidt, Z. f. Metallkunde, 49,
h.3, 1958).   Examining the dependence of the specific resistance,
the Nernst-Ettinghausen constant, the absolute thermal emf,
Young's modulus and the electrical conductivity on the
theoretical electron concentration n in all three systems, it is
observed that the higher the valency of the alloying element the
faster do the above properties change with increasing n .   The
Hall constant does not follow this rule.   A well defined
dependence of the above properties on the electron concentration
is not, however, displayed.   There are 6 figures.

ASSOCIATION: Moskovskiy institut stali (Moscow Steel Institute)

SUBMITTED: July 17, 1961

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372uu

S/148/62/000/003/009/011
E111/E435

/f.11f/

AUTHORS: Lakhman, N.G., Livshits, B.G.

TITLE: Electric resistance and modulus of elasticity of
             Fe-Al alloys with Mo

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy.
             Chernaya metallurgiya, 5, no.3, 1962, 125-134

TEXT: The object of the present work was to study the influence
of alloying with molybdenum on phase changes in iron-aluminium
alloys.   This information is needed to find the best heat
treatment and pressure-working conditions for these ternary
alloys, which are becoming increasingly important as magnetically
soft and as scaling and corrosion resistant materials.   The
alloys studied were 14% Al and 1, 2, 3 and 4% Mo.   Ingots of the
alloys were formed into 0.35 mm thick strip or 6 mm diameter rod.
In addition to the temperature dependence of the electrical
resistance and the modulus of elasticity, the change in resistance
when specimens, water-quenched from 900°C, were tempered at
150 to 600°C for 5 min to 20 hours was studied.   With all alloys
resistance was found to rise greatly up to 500°C and then fall,   )(
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S/148/62/000/003/009/011
Electric resistance ...   · E111/E435

with some tendency to rise at 800 to 1000°C.   The slope of the
temperature curves increases the closer the approach of the initial
state to equilibrium.   Two processes could be occurring in the
ternary alloys: ordering, associated mainly with falling
resistance and taking place at relatively low temperatures;
another process producing an anomalous change in resistance
(K-state), particularly evident at 1 and 2% Mo and possibly due to
loss of molybdenum atoms from the solid solution.   When tempered
at 150 to 450°C, all the alloys showed a fall in resistance
compared with that in the quenched state, the fall being
appreciable (6 to 8%) with tempering for 5 min and largely
complete with 1 hour's tempering.   The temperature corresponding
to the minimum varied with tempering time.   .Tempering at 500 to
600°C caused an increase in resistance.   The changes are
probably due to order-disorder effects, molybdenum having a
disordering effect: as its concentration rises from 1 to 4%, the
maximum fall in resistance after tempering decreased from 18 to
11% and was reached at a lower temperature.   It is possible that
there are two stages in ordering, the second stage being
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Electric resistance ...

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E111/E435

gradually weakened when Mo concentration rises to 3 to 4%.
At tempering temperatures over 500°C, a superlattice effect may be
involved.   Alloying with molybdenum greatly affects the influence
of temperature on the modulus of elasticity.   With 1% Mo, the
modulus falls with rising temperature to about 500°C, then stays
fairly constant to about 650°C and falls sharply at higher
temperatures.   With 2% Mo, the modulus falls to 500°C, then rises
to a maximum at about 750°C and falls sharply.   The effect with
3% Mo is similar but less pronounced;   for alloys with 4% Mo,
the fall continues throughout the range studied (up to 850°C).
There are 5 figures.

ASSOCIATION: Moskovskiy institut stali
             (Moscow Steel Institute)

SUBMITTED: June 16, 1961

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37245

S/148/62/000/003/010/011

E073/635

/8.1Y/0

AUTHORS: Belyatskaya, I.S., Kostin, L.K., Livshits, B.G.

TITLE: The influence of the K - state on the creep strength
             of nickel-chromium base alloys

PERIODICAL: Izvestiya vysshikh uchebnykh zavedeniy.   Chernaya
             metallurgiya, no. 3, 1962, 135

TEXT: Earlier investigation of the authors of this paper
showed that a nickel base alloy containing 15.8% Cr; 1.99% Ti;
1.78% Al; 5.22% W; 0.26% V; 3.89% Mo; 1.39% Fe; 0.05% B; 0.09% C
had a time-to-failure twice as long after additional treatment
for the K - state than the same specimens after standard heat
treatment.   However, no such an improvement in properties
occurred in the nickel base alloy containing 14.55% Cr; 1.93% Ti;
1.93% Al; 5.52% W; 0.25% V; 3.40% Mo; 1.08% Fe; 0.005% B; 0.07%C.
Two heats of the alloy ЭИ617 (EI 617) subjected to a heat treat-
ment as proposed by the authors were also investigated for creep
strength.   The specimens of one of the heats were additionally
treated to achieve the K - state and, after being tested for
creep strength for a period twice as long as specimens subjected

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S/126/62/013/001/003/018
E193/E383

AUTHORS: Kekalo, I.B. and Livshits, B.G.

TITLE: Effect of intensity of magnetization on the
             temperature dependence of the internal friction of
             nickel

PERIODICAL: Fizika metallov i metallovedeniye, v.13, no. 1,
             1962, 54 - 61

TEXT: The object of the present investigation was to
establish the origin of an internal-friction peak observed by
some workers in nickel at 100 °C. Since it was known that the
magnetic properties of nickel undergo an anomalous change at
100 °C, it was considered most likely that there was a
relationship between the internal-friction peak and the
specific nature of the magnetic properties of nickel; hence -
the line of approach chosen by the authors in their experimental
study, conducted in vacuum on wire specimens 300 mm long, 0.7 mm
in diameter. The impurity content in the experimental material
did not exceed 0.05% and all the specimens except one were

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Effect of intensity ....

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E193/E383

subjected to the same preliminary heat treatment (30 min at
800 °C, followed by slow cooling to room temperature). The
results can be summarized as follows: the temperature
dependence of internal friction of nickel has two maxima at
about 100 and 440 °C. The high-temperature peak is associated
with relaxation at the grain boundaries, whereas the peak at
100 °C and its characteristics are related to the anomalous
variation of magnetic properties of nickel at this temperature.
The height of the low-temperature peak increases when the
specimen is in the state of residual induction or when it is
magnetized in weak (9 Oe) magnetic fields. The low-temperature
peak is absent in . specimens placed in strong magnetic fields.
The internal-friction background increases in weak fields and
reaches a minimum value in a field of the order of several
hundreds of Oe. Increasing the reduction given to the wire
specimens (during wire-drawing) before the final annealing
treatment brings about a decrease in the height of the low-
temperature internal-friction peak which is absent on

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Effect of intensity S/126/62/013/001/003/018
                                   E193/E383

curves constructed for cold-worked material.
There are 4 figures.

ASSOCIATION: Moskovskiy institut stali
                (Moscow Institute of Steel)

SUBMITTED: November 23, 1960

Card 3/3

18.1160

S/126/62/013/002/005/019
E193/E383

5

AUTHORS: Livshits, B.G. and Rymashevskiy, G.A.

TITLE: K-state and atomic-bond forces in nickel-base single-phase solid solutions

PERIODICAL: Fizika metallov i metallovedeniye, v. 13, no. 2, 1962, 199 - 208

TEXT: In a large majority of earlier investigations the formation of the K-state had been studied by measuring the hardness, electrical resistance, magnetic properties and other similar characteristics of alloys. As a result, no direct conclusions could be drawn regarding the nature of this structural state. Starting from the premises that a solution of this problem is more likely to be found by studying properties which characterize the atomic-bond forces in metals, the present authors studied the variation in the elastic modulus, shear modulus and Debye temperature of several alloys in which the formation of the K-state takes place. The experimental materials comprised the following nickel-base single-phase alloys: Ni_3Mn; Ni_3Fe + up to 7.5 at.% Mo; Ni + Co + up to
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20

25

30

K-state and ....

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E192/E383

9.7 at.% V; Ni-Cr alloys containing 19, 24, 31 and 35 at.% Cr. The experimental test pieces were first quenched from high (1000- 1 200 $^{\circ}$C) temperatures and the variation of the properties studied during subsequent ageing was correlated with the variation in electrical resistance. Some of the results are tabulated and reproduced graphically. In Fig. 1 the relative increase in the shear modulus $\Delta G/G_{3\eta <}$, % and Debye temperature $\Delta\Theta/\Theta_{30K}$, %, during ageing of the Ni_3Fe alloy, is plotted against the relative decrease ($\Delta\rho/\rho_{30K}$, %) in its electrical resistivity; here, ΔG, $\Delta\Theta$ and $\Delta\rho$ are the increments due to ageing, G_{30K}, Θ_{30K} and ρ_{30K} denote the values of these properties for the alloy in the as-quenched condition. The $\Delta G/G_{30K}$ versus $\Delta\rho/\rho_{30K}$ curves for nichrome with various chromium contents are reproduced in Fig. 2. The $\Delta\rho/\rho_{30K}$ of Ni_3 + Mo alloys is plotted against the

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K-state and ....

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E192/E382

Mo content in Fig. 3. In Fig. 4, $\Delta G/G_{3\alpha K}$ (upper diagram) and $\Delta\vartheta/\tilde{\ }_{3\Pi K}$ (lower diagram) for Ni_3Fe + Mo alloys aged at 380 °C for 620 min are plotted against the Mo content. Several conclusions were reached.

1) Both disorder-order transformation and formation of the K-state bring about an increase in the atomic-bond forces.

2) Formation of the K-state in nichrome containing less than 50 at.% Cr consists most likely of localized ordering of the Ni_2Cr type, accompanied by nickel enrichment of the domain boundaries.

3) The variation in properties studied during ageing of alloys of the A_3B) C type can be explained on the basis of the assumption that formation of the K-state consists, in this case, of the segregation of atoms of the third element (C), the regions denuded of this element undergoing a disorder-order transformation of the A_3B type.
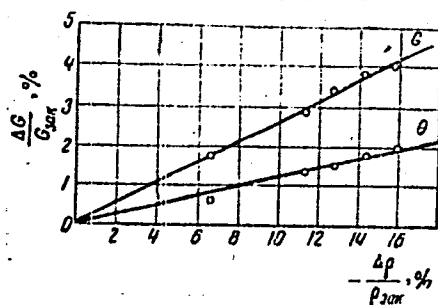
Card 5/5

K-state and ....

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E192/E382

The process of formation of the K-state cannot be explained in terms of ordering alone, although in some cases ordering plays a predominant part.   There are 5 figures and 4 tables.

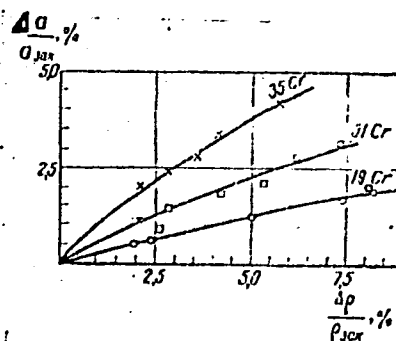ASSOCIATION: Moskovskiy institut stali (Moscow Institute of Steel)

SUBMITTED: January 2, 1961

Fig. 1:

Fig. 2:

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/8./100

37702
S/126/62/013/004/016/022
E193/E383

AUTHORS: Kekalo, I.B. and Livshits, B.G.

TITLE: Magnetic-field dependence of the internal friction and shear modulus of nickel

PERIODICAL: Fizika metallov i metallovedeniye, v. 13, no. 4, 1962, 599 - 608

TEXT: The object of the present investigation was to study the effect of a constant and alternating magnetic field on the internal friction of nickel at various amplitudes of elastic vibrations, the torsion-pendulum method being used for internal-friction measurements. In addition, the field dependence of the shear modulus of Ni was studied. The investigation was undertaken for the following reasons: 1) the low-frequency method of torsion pendulum was used to study the magnetic losses by a few investigators only, who obtained contradictory results; 2) the amplitude-dependence of the internal friction of Ni in a wide range of constant and alternating fields has not

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Magnetic-field dependence S/126/62/013/004/016/022
                                  E193/E383

yet been studied;
3) no attempt has yet been made to correlate data on internal-
friction and on the elastic characteristics of Ni determined in
constant and alternating fields. The experimental work was
carried out on wire specimens of Ni containing less than 0.5%
impurities, preliminarily vacuum-annealed at 800 °C. The
main results are reproduced in Fig. 6, where the internal-
friction ($Q^{-1} \times 10^4$, graph a) and variation in shear modulus
($\Delta G/G$, % - graph 6) are plotted against the magnetic-field
strength, curves 1 and 1' relating to data obtained in a
constant magnetic field on specimens annealed at 900 °C,
curves 2 and 2' relating to results obtained in alternating
magnetic fields on specimens annealed at 600 °C. These and
other results can be summarized as follows: L the internal-
friction peak is observed in Ni in both constant and alternating
magnetic fields. The height of the peak in alternating fields
is almost ten times greater than that in constant fields, the
peak in the alternating field being displaced towards a low

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Magnetic-field dependence ....

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field intensity. 2. The height of the peak increases with
increasing amplitude of the elastic vibrations, this relationship
being linear in constant fields and nonlinear in alternating
fields. 3. The internal friction of Ni is proportional to the ampli-
tude of elastic vibrations, both in the absence of a magnetic
field and in constant fields of varying intensity. A nonlinear
relationship between the internal friction of Ni and the
amplitude of elastic vibrations is observed in constant fields
in the intensity range within which the internal friction reaches
its maximum value. 4. A negative ΔG effect is observed in Ni,
both in constant and alternating magnetic fields, the effect
being several times greater in alternating fields. The height
of the magnetic internal-friction peak and the value of the
negative ΔG effect are interdependent and so are the field
intensities corresponding to the maximum value of internal
friction and minimum value of the ΔG effect.
5. The magnetic internal friction studied in the course of the
present investigation by the low-frequency torsion-pendulum
method is associated with losses on magneto-elastic hysteresis.

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The results obtained are discussed in terms of the theory of reversible and non-reversible elementary magnetic phenomena taking place in ferromagnetic materials under the action of magnetic and elastic forces. There are 7 figures.

ASSOCIATION: Moskovskiy institut stali
(Moscow Institute of Steel)

SUBMITTED: August 12, 1961

Card 4/6.4